Scientific Papers. Series A. Agronomy, Vol. LIX, 2016
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF SOWING TIME ON PEANUT (*Arachis hypogaea* L.) CULTIVARS: I. YIELD, YIELD COMPONENTS, OIL AND PROTEIN CONTENT

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Abstract

The objectives of this research were to investigate the effects of sowing time and cultivar on pod yield, yield components, oil and protein content of peanut crops under irrigated condition in south-eastern of Turkey. Three peanut cultivars, Halis Bey, Osmaniye-2005 and Sultan developed by Cukurova University were grown at the experimental area of Agricultural Faculty, Dicle University, Diyarbakir, Turkey in 2010 and 2012 with two sowing times (15 April as early sowing and 25 June as late sowing). Treatments were arranged in split plot design replicated three times with sowing time in the main plots and cultivars in the subplots. Sowing time affected pod yield, pod number plant^{-1} and oil content in both years. Early sowings resulted in higher pod yields, pod number plant^{-1} and oil content compared to late sowing for all cultivars. The results also showed that cultivars were different for pod yield in both years. Sultan produced the highest pod yields under both sowing times.

Key words: *Arachis hypogaea, peanut, sowing time, cultivar, yield, oil, protein.*

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is one of the important oilseed crops that occupies an area of 24.7 million hectares with production of 41.1 million tons in the world. In Turkey, total area harvested was 37.3 thousand hectares with production of 120 thousand tons (FAO, 2012). Peanut seeds are a good source of proteins, lipids, and fatty acids for human nutrition. They are rich in oil, naturally containing from 47 to 50% (Sanders, 2002).

Growth and yield of a crop depend on a number of factors; however, climate plays the most important role. Among the climatic parameters role of solar radiation, temperature, humidity, rainfall is very crucial. The oilseed crops, particularly peanut are very sensitive to climatic parameters such as radiation and temperature (Banik et al., 2009). Crop management practices such as time of sowing and duration of cultivar life cycle may influence pod yield, yield parameters and quality of peanut. Peanut is mainly sown in spring season (April-May) as main crop in southern of Turkey. Furthermore, in the southern and southeastern regions, peanut can be grown in the wheat fallows during post-rainy season if irrigation facilities are available. In southern of Turkey, peanut crop duration is shorter in second cropping system (late June), with lower temperature apparently affecting crop maturity. Thus, peanut crop will not reach optimum maturity for a marketable yield to justify commercial production in areas with fewer heat units during the growing season, especially when it is grown in double cropping system. The actual impact of seed maturity is dependent on genotype, climatic conditions, and genotype x climate interactions. Variations in weather patterns affect the length of growing season as well as flowering date and pod development. Stern (1968) suggested that declining minimum temperatures in later plantings may have retarded or even prevented pod development. Temperature has been found to affect oil and protein concentration of seeds of several species depending upon the combination of genotype and temperature regime (Golombek et al., 2001). The objective of this research was to compare the effect of two sowing times on yield, yield components, oil and protein content of three peanut cultivars grown under irrigated conditions in southern Turkey.

MATERIALS AND METHODS

The study was carried out at University of Dicle, Faculty of Agriculture, Field Crops Department, Diyarbakir located in South East Anatolian Region of Turkey in 2010 and 2012 growing seasons. Because of problem in irrigation system of the experimental field, the study cannot be carried out in 2011, so we had to delay the study to 2012. The region has a warm climate in summer, and the mean annual rainfall is around 450 mm, most of which fall in a major cropping season which extends from November to June. Thus, peanut can be grown during double cropping season with irrigation in cereal or food legume-based cropping systems in the region. Monthly air temperature, rainfall and humidity for 2010 and 2012 were presented in Table 1. The treatments were replicated three times in split plot based on randomized complete block design with two sowing times (mid-April as main crop, and late June as second crop after wheat harvest) in the main plots and three cultivars (Halis Bey, Osmaniye 2005 and Sultan) developed at Cukurova University in the sub-plots. The size of each plot was 2.8 x 5.0 m. Row spacing (four rows) was 0.7 m and the distance between plants in the row was 0.20 m, providing a sowing density of 7.2 plants m^2. On the basis of soil analysis, the crop was fertilized with 100 kg N and 100 kg P_2O_5 ha^{-1} applied as basal dose in the form of 20-20-0 fertilizer prior to sowing. In addition, top dressing nitrogen was provided at the time of full flowering stage at the rate of 100 kg ha^{-1} as ammonium nitrate (33% N) for all plots. Weeds were controlled by both Trifluralin (2.5 L ha^{-1}) as pre plant and by hand as needed. The field was uniformly irrigated at 10-day intervals until harvest period using overhead sprinklers. All plots were harvested from two central rows at mid-November in 2010 and 2012. At harvest, 10 peanut plants from each plot were taken to determine 100-seed weight, pod number $plant^{-1}$ and shelling percentage = (seed yield/ pod yield] x 100. Pod yields were determined by harvesting the whole plot area. Unshelled samples were sun dried for one week. The shelled pods by hand were again sun dried for two days, thereafter analyzed for oil and protein content. The seed samples were ground, the oil was extracted with diethyl ether using soxhlet apparatus.

Table 1. Monthly temperature (°C), rainfall (mm) and humidity (%) in 2010 and 2012 growing seasons (Diyarbakir Turkish State Meteorological Service)

Months	Temperature (°C)						Rainfall (mm)		Humidity (%)	
	Min.		Max.		Mean					
	2010	2012	2010	2012	2010	2012	2010	2012	2010	2012
April	1.4	2.0	26.7	27.8	14.2	15.2	22.4	26.2	60	58
May	7.0	8.6	34.1	33.0	20.4	19.6	31.6	41.0	49	58
June	11.7	9.4	42.0	41.7	27.2	27.7	11.2	7.0	29	28
July	17.7	14.5	43.3	43.7	32.3	31.3	0.0	1.6	20	21
August	17.2	17.1	42.7	41.0	32.0	31.1	0.4	0.0	21	26
September	13.8	12.8	39.7	37.9	27.0	26.1	0.0	1.8	27	23
October	3.9	7.3	31.0	35.6	18.1	18.4	63.0	107.4	56	55

Protein content was measured as N×6.25 after analysis with N analyzer (Leco FP-2000; Leco Corp., St. Joseph, MI). Data were analyzed separately by year. The statistical significance of differences in the traits between groups was analyzed with analysis of variance (ANOVA) and Tukey's HSD test using a statistical software package (JMP version 5.0.1a); $P<0.05$ was taken to indicate a statistically significant difference.

RESULTS AND DISCUSSIONS

Data in Table 2 indicated that sowing time had significant effect on pod yield, pod number $plant^{-1}$ and oil content in both years. Furthermore, significant differences were observed regarding 100-seed weight and protein content between sowing time in 2010. Non-significant differences were observed among used cultivars regarding most of all traits examined except of pod yield in both years and pod number $plant^{-1}$ in 2010. The interaction between sowing time and cultivar treatments was only significant on pod yield in 2012 and pod number $plant^{-1}$ in 2010.

Table 2. Analysis of variance for yield, yield components, oil and protein content of different peanut cultivars at two sowing times in 2010 and 2012[a]

Year/Sowing time/Cultivar	Pod yield (kg/ha)	100 seed weight (g)	Pod number plant^{-1}	Shelling percentage (%)	Oil content (%)	Protein content (%)
2010						
Sowing time (T)	*	*	*	ns	*	*
Cultivar (C)	**	ns	**	ns	ns	ns
T X C	ns	ns	*	ns	ns	ns
2012						
Sowing time (T)	**	ns	**	ns	*	ns
Cultivar (C)	**	ns	ns	ns	ns	ns
T X C	**	ns	ns	ns	ns	ns

[a]All values are means of three replications. ns, *, ** correspond to non-significant or significance at P<0.05 and 0.01, respectively.

Sowing time led to different pod yields of 4942.9 kg ha^{-1} and 5175.5 kg ha^{-1} in early and 3543.0 kg ha^{-1} and 3550.3 kg ha^{-1} in late sowing time in 2010 and 2012, respectively. The longer growing season in early sowing time resulted in a better pod yield performance. Thus, the early sowing time resulted in 39.0% and 45.7% pod yield increase (in 2010 and 2012, respectively).

Table 3. Effect of different cultivars on pod yield (kg ha^{-1}) of peanut at early and late sowing time in 2010 and 2012

Cultivar/ Sowing Time	2010			2012		
	Early	Late	*Mean*	Early	Late	*Mean*
Halis Bey	4902.0	3707.3	*4304.6a*	4502.6b	3501.7c	*4002.1b*
Osmaniye	4640.5	3339.3	*3989.9b*	5525.4a	3414.9c	*4470.1a*
Sultan	5286.4	3582.4	*4434.4a*	5498.5a	3735.3c	*4616.9a*
Mean	*4942.9a*	*3543.0b*	*4242.9*	*5175.5a*	*3550.3b*	*4362.9*
LSD_T		*652.2*			*121.6*	
LSD_C		*269.8*			*372.5*	
LSD_{TXC}		-			*673.5*	

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P>0.05)

Canavar and Kaynak (2008) reported that pod yield of peanut was affected by sowing time, with early sowing resulting in highest yields. Also, Laurence (1983) reported that late sowing reduced pod yields by 19% (from 5.02 to 4.21 t/ha) compared with early sowing. In the present study, the relatively low yield for late sowing in both years averaged across all cultivars was likely due to the shortening of crop growth cycle by delayed sowing. Sultan and Halis Bey produced a significantly higher pod yield as compared to Osmaniye-2005 in 2010, while Halis Bey had the lowest pod yield in 2012. In respect of sowing time x cultivar interaction in 2012, the highest pod yield was obtained from Osmaniye-2005 and Sultan in early sowing time (5525.4 and 5498.5 kg ha^{-1}, respectively).

100-seed weight decreased from 72.45 to 65.93 g in 2010 and from 109.81 to 97.98 g in 2012 with delay in sowing time. Thus, early sowing produced more 100-seed weight than the late sowing by 10 and 12% in 2010 and 2012, respectively. This can be related to the lower temperatures at seed filling stage in late sowing which resulted in delayed maturity.

Table 4. Effect of different cultivars on 100-seed weight of peanut at early and late sowing time in 2010 and 2012

Cultivar/ Sowing Time	2010			2012		
	Early	Late	*Mean*	Early	Late	*Mean*
Halis Bey	72.27	64.90	*68.58*	102.79	94.70	*98.75*
Osmaniye	70.57	68.73	*69.65*	117.47	97.50	*107.48*
Sultan	74.53	64.17	*69.35*	109.15	101.73	*105.44*
Mean	*72.45a*	*65.93b*	*69.19*	*109.81*	*97.98*	*103.89*
LSD_T		*4.30*			-	
LSD_C		-			-	
LSD_{TXC}		-			-	

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P>0.05)

This result confirm the finding of Bala *et al*. (2011) who reported that delayed sowing delayed 50% flowering and peanut plants accumulated less dry matter as sowing was delayed. Although there were not differences among cultivars tested for 100 seed weight it was within the range of 68.58-69.65 g in 2010

and 98.75-107.48 g in 2012 obtained for three cultivars. Osmaniye-2005 gave numerically the highest 100-seed weight while Halis Bey had the lowest value in both years.

Pod number plant^{-1} was significantly influenced by sowing time in both years.

Table 5. Effect of different cultivars on pod number plant^{-1} of peanut at early and late sowing time in 2010 and 2012

Cultivar/ Sowing Time	2010			2012		
	Early	Late	*Mean*	Early	Late	*Mean*
Halis Bey	36.00b	27.67bc	*31.83a*	36.37	27.63	*32.00*
Osmaniye	30.33bc	23.67c	*27.00b*	43.00	24.76	*33.88*
Sultan	44.67a	27.00c	*35.83a*	39.76	31.27	*35.52*
Mean	*37.00a*	*26.11b*	*31.55*	*39.71a*	*27.89b*	*33.80*
LSD_T		*7.69*			*0.67*	
LSD_C		*4.66*			-	
LSD_{TXC}		*8.42*			-	

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P>0.05)

Pod number plant^{-1} declined as much as 42% in both years. Similar influence of sowing time on pod number plant^{-1} had been reported by Murthy and Rao (1986) who attributed this to shortening of maturation period in the late sowing. Bell (1986) reported that pod numbers were more sensitive to sowing time than pod yield. Pod number plant^{-1} which ranged from 27.00 to 35.83 was significantly influenced by cultivars only in 2010. Sultan and Halis Bey produced more pod number plant^{-1} than that of Osmaniye-2005 (Table 5). In case of sowing time x cultivar interaction significant differences were observed for pod number plant^{-1} in 2010. In 2010, pod number plant^{-1} for Sultan was the highest for early sowing time. In 2012, Osmaniye-2005 had the highest pod number when sowing early although there was no significant difference statistically.

There were no significant differences in shelling percentage for sowing time, cultivar or sowing time x cultivar interaction in both years (Table 2). However, shelling percentage in early sowing time was numerically higher than that of late sowing, especially in 2010. This can be related to the lower soil temperature in seed filling period which resulted in delayed maturity.

Table 6. Effect of different cultivars on shelling percentage (%) of peanut at early and late sowing time in 2010 and 2012

Cultivar/ Sowing Time	2010			2012		
	Early	Late	*Mean*	Early	Late	*Mean*
Halis Bey	51.90	46.90	*49.40*	61.67	58.77	*60.22*
Osmaniye	51.63	44.93	*48.28*	63.00	60.63	*61.82*
Sultan	49.97	47.17	*48.57*	61.67	63.13	*62.40*
Mean	*51.17*	*46.33*	*48.75*	*62.11*	*60.84*	*61.48*
LSD_T		-			-	
LSD_C		-			-	
LSD_{TXC}		-			-	

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P>0.05)

In respect to cultivar, Halis Bey had the highest shelling percentage in 2010 whereas it had the lowest value in 2012. In 2012, the highest shelling percentage obtained from Sultan (Table 6).

Analyzed data revealed that there was significant effect on oil content by different sowing times in both years. Early sowing peanut produced significantly higher contents of oil (Table7).

Table 7. Effect of different cultivars on oil content (%) of peanut at early and late sowing time in 2010 and 2012

Cultivar/ Sowing Time	2010			2012		
	Early	Late	*Mean*	Early	Late	*Mean*
Halis Bey	50.90	48.50	*49.70*	51.63	49.37	*50.50*
Osmaniye	52.10	49.27	*50.68*	51.50	49.80	*50.65*
Sultan	51.23	49.23	*50.23*	52.70	49.80	*51.25*
Mean	*51.41a*	*49.00b*	*50.20*	*51.94a*	*49.65b*	*50.80*
LSD_T		*1.91*			*1.33*	
LSD_C		-			-	
LSD_{TXC}		-			-	

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P>0.05)

Between the early and the late sowing times, decrease in oil contents were 4.9% and 4.6% in 2010 and 2012, respectively. This may be because of the shorter growing season and cooler climate during seed filling stage (September-October) in late sowing time (Table 1). Higher temperatures during the period from seed filling stage to harvest increased oil content in the seed. The results of our study is also in line with the finding of Pritchard *et al.* (2000), Yousaf *et al.* (2002) and Ozer (2003) who also reported that delayed sowing decreased oil levels in rapeseed. Data

reported by several researcher also indicates that relatively hot dry conditions in seed filling period may favor high oil content in *Camelina sativa* (Gugel and Falk, 2006). However, the oil content was not affected significantly by used cultivars, and sowing time x cultivar interaction. Among the cultivars, the highest oil content was obtained from Osmaniye-2005 and the lowest oil content was obtained from Halis Bey in both years with insignificant differences among cultivars (Table 7). Seed oil content is purely genetically controlled character and plays vital role in determining total oil yield per unit area.

Protein content was significantly influenced by sowing time in 2010. Contrary to oil content, higher protein content was recorded for plants obtained from late sowing times (Table 8).

Table 8. Effect of different cultivars on protein content (%) of peanut at early and late sowing time in 2010 and 2012

Cultivar/ Sowing Time	2010			2012		
	Early	Late	*Mean*	Early	Late	*Mean*
Halis Bey	22.82	23.61	23.21	21.70	22.60	*22.15*
Osmaniye	22.00	24.25	23.13	21.10	22.87	*21.98*
Sultan	21.09	24.02	22.55	21.33	22.33	*21.83*
Mean	*21.97b*	*23.96a*	*22.96*	*21.38b*	*22.60a*	*21.99*
LSD_T		*1.77*			-	
LSD_C		-			-	
$LSD_{T\,X\,C}$		-			-	

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P>0.05)

The reasons of higher protein content in late sowing could be explained by lack of seed maturation resulted in shorter seed filling period. Results from previous research on the effect of sowing time on protein content were consistent with our result. For example, Canavar and Kaynak (2013) reported that protein content of peanut seed was increased by delaying the harvest time. Also, Golombek et al. (2001) indicated that a decrease in pod temperature lowered the protein concentration at a root temperature of 28/22 ^{0}C, whereas it increased protein concentration at a root temperature of 40/34 ^{0}C. In 2012, protein contents of peanut seeds decreased from 22.60 to 21.38% with early sowing times, but were not significant affected. Non-significant differences were observed among used cultivars and sowing time x cultivar interaction regarding protein content. However, Sultan contained slightly lower protein of 22.55% and 21.83% in 2010 and 2012, respectively as compared to other cultivars in both sowing times.

CONCLUSIONS

It can be concluded that peanut was significantly affected by sowing time. The late-sown crops matured during lower temperature conditions than did the early-sown crops. In all of the early sown crops, the duration of oil accumulation in the seeds was longer where it coincided with a period of particularly high temperatures. Thus, under ecological conditions in south-eastern of Turkey, early sowing time at the mid-April led to increases in pod yield and oil content compared to late sowing time. However, it is possible to obtain over 3500 kg ha^{-1} pod yield, which is considered as acceptable level by the grower in the region with shorter growth duration in double crop production. In respect to cultivar tested, Sultan produced the highest pod yields under both sowing times.

ACKNOWLEDGEMENTS

This research was founded by DUBAP (Dicle University Scientific Research Projects) Unit, Project No. 08-ZF-56.

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